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TIMOTHY RUST IN THE UNITED STATES.

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TIMOTHY RUST IN THE UNITED STATES.

DISTRIBUTION OF THE RUST OF TIMOTHY.

Rust of timothy was reported in this country by Trelease as early as 1882.[1] Farlow and Seymour, on the basis of this report, mentioned *Puccinia graminis* on *Phleum pratense* L. from the United States in their "Host Index of the Fungi of the United States" (1888). Rust of timothy was reported as causing considerable damage in the experimental plats at the Iowa experiment station in 1891.[2] From 1891 to 1906 the parasite seems to have been little in evidence throughout the country, and the writer has been unable to find any mention of it during those years.

In 1906 the rust became epidemic in the experimental plats at the Arlington Experimental Farm. In 1907 it was epidemic at points in New York and Virginia; it was also reported from Delaware, West Virginia, and Ontario, Canada. In 1908 this rust was widespread and caused much damage in New York, Pennsylvania, Delaware, Maryland, and Virginia; it was also reported from West Virginia, Ohio, Michigan, Wisconsin, and Minnesota. In 1909 the rust was common in many of the States mentioned and in addition was reported from Indiana, Kentucky, Iowa, and Maine. In 1910 it was observed in many States from which it had been previously reported, and in considerable quantity in Virginia, New York, Michigan, and Minnesota. In the last State it was collected at both New Richland and Owatonna, and in August was exceedingly abundant in timothy pastures around Crookston. Thus, from being only locally observed in 1906, this rust was widespread in 1909 and 1910, having been reported from Maine to Ontario and northern Minnesota, and south to Iowa, Kentucky, and Virginia.[3]

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[1] Trelease, William. Parasitic Fungi of Wisconsin. Transactions of the Wisconsin Academy of Sciences, 1882, p. 131. A specimen collected in Wisconsin was kindly sent to us for examination by Dr. Trelease from the Missouri Botanical Gardens. It was rather unsatisfactory, as it consisted of only one rusted leaf, and thus may have been inaccurately determined, leaving some doubt as to the authenticity of this early report.

[2] Wilson, J., Curtis, C. F., and Kent, D. A. Time of Sowing Grass Seed. Bulletin 15, Iowa Agricultural Experiment Station, 1891, pp. 285–286.

[3] The writer is indebted to botanists and plant pathologists at the various agricultural experiment stations and to J. J. Davis, M. W. Evans, E. M. Freeman, R. A. Harper, Frank D. Kern, W. J. Morse, C. V. Piper, H. N. Vinall, H. J. Webber, and others who have answered letters of inquiry in regard to the rust on timothy or have given information as to its prevalence in various localities.

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DESCRIPTION OF TIMOTHY RUST.

The timothy rust is very similar in general appearance and morphological characteristics to *Puccinia graminis* Pers. on wheat. It attacks both leaf and stem, forming long, yellowish-brown uredo pustules and dark-brown to black teleuto pustules, which rupture the epidermis. At times it also attacks the head, often preventing the formation of seed. The uredospores are most prevalent, while the teleutospores are less abundant.

The uredospores are 18 to 27 μ in length and 15 to 19 μ in width; the teleutospores, 38 to 52 μ in length and 14 to 16 μ in width. This is the same range as that of the corresponding spores of *Puccinia graminis* Pers. on wheat, but the variation is not quite as great as in the wheat rust. The teleutospores are constricted in the middle and have a much thickened, round or pointed apex and pedicels of medium length, and closely resemble those of the typical *Puccinia graminis* Pers.

RELATIONSHIP AND PHYSIOLOGICAL SPECIALIZATION OF TIMOTHY RUST.

In 1908 and 1909 inoculation experiments on various grasses were undertaken at Washington, D. C., to determine the relationship of the rust of timothy to rusts of other hosts in this country and to ascertain whether or not it is the same form as that which occurs in Europe. Collections were made at the Arlington Experimental Farm, and fresh material in the uredo stage was kept growing in the greenhouses at Washington, D. C. All inoculations were made on young, fresh leaves of the host plants growing in pots. The plants were kept moist for 48 hours after inoculation by placing the pots in moist chambers consisting of large bell jars placed in pans containing sand and a little water. In this way a thin film of water soon condensed on the leaves and remained as long as the plants were covered. This gave ideal conditions for spore germination and for infection. The results of these inoculations are reported in Table I.

TABLE I.—*Results of experiments in inoculating various grasses with uredospores of rust.*

Serial No.	Date of inoculation.	Source of inoculating material.	Varieties of plants inoculated.	Number of leaves inoculated.	Number of successful infections during incubation period of 17 to 21 days.
1	Jan. 25, 1908	Phleum pratense	Triticum vulgare	10	0
2	Feb. 3, 1908	Triticum vulgare	Phleum pratense	25	0
3	Jan. 25, 1908	Phleum pratense	Hordeum vulgare	10	0
4	do	do	Avena sativa	10	6
5	Feb. 18, 1908	do	do	20	11
6	Feb. 3, 1908	Avena sativa	Phleum pratense	23	0
7	do	Phleum pratense	do	25	19
8	Jan. 25, 1908	do	Secale cereale	5	1
9	Feb. 18, 1908	do	do	36	7
10	Feb. 7, 1908	do	Festuca elatior	24	6
11	Feb. 4, 1909	do	do	42	0
12	Feb. 20, 1908	do	Dactylis glomerata	22	6
13	Jan. 23, 1909	do	do	25	1
14	Feb. 4, 1909	do	do	16	6
15	Feb. 13, 1909	do	do	59	9
16	Feb. 20, 1908	do	Arrhenatherum elatius	18	0
17	Jan. 27, 1909	do	do	18	6
18	Feb. 4, 1909	do	do	3	2
19	do	do	Poa compressa	18	6
20	Feb. 8, 1909	do	do	29	7
21	do	do	Poa pratensis	33	0
22	Feb. 7, 1908	do	Elymus virginicus	60	0
23	Jan. 27, 1909	do	do	33	0
24	Feb. 4, 1909	do	do	10	0
25	Jan. 23, 1909	do	Elymus canadensis	25	0
26	Feb. 8, 1909	do	do	9	0
27	Mar. 7, 1908	do	Elymus robustus	16	0
28	Feb. 20, 1908	do	Agropyron occidentale	14	0
29	do	do	Hordeum jubatum	24	0
30	Mar. 7, 1908	do	Phalaris arundinacea	17	0
31	do	do	Holcus lanatus	28	0
32	Feb. 4, 1909	do	Hystrix hystrix	44	0
33	Feb. 8, 1909	do	Agrostis alba	31	0
34	Feb. 13, 1909	do	do	11	0
35	Jan. 23, 1909	do	Bromus unioloides	40	0
36	Jan. 27, 1909	do	do	7	0

The rust rather easily transferred to *Avena sativa* (17 out of 30 inoculations), *Secale cereale* (8 out of 41 inoculations), *Festuca elatior* [1] (6 out of 66 inoculations), *Dactylis glomerata* (22 out of 122 inoculations), *Arrhenatherum elatius* (8 out of 47 inoculations), and *Poa compressa* (13 out of 47 inoculations). Inoculations on other grasses produced no infection. Similar results were obtained by Eriksson [2] in inoculation experiments with this rust on *Avena sativa*, *Secale cereale*, and *Festuca elatior*.[1] No inoculations on *Dactylis glomerata*, *Arrhenatherum elatius*, or *Poa compressa* are cited in his report. Direct inoculation on *Triticum vulgare* and *Hordeum vulgare* gave negative results in 10 trials each, thus corresponding to the negative results in numerous similar trials of Eriksson.[2] From these

[1] The tall meadow fescue was used in our work. It is probable that the same variety was used by Eriksson, as this is the common form known by that name in Sweden.

[2] Eriksson, Jakob. Ist der Timotheengrasrost eine selbständige Rostart oder nicht? Öfversigt af Kongliga Svenska Vetenskaps-Akademiens Förhandlingar, no. 5, 1902, pp. 193–196.

experiments it may be concluded that the rust in the United States and the rust in Europe are identical, and the statement by Eriksson [1] that it is not a well-fixed species is substantiated. Although timothy rust can easily be transferred to *Avena sativa*, Eriksson [1] and Carleton [2] have shown that the uredo of *Puccinia graminis avenae* Erikss. and Henn. can not be made to grow on timothy. This rust, however, can easily be transferred to *Dactylis glomerata* and *Arrhenatherum elatius*.[2] Timothy rust also transfers to these hosts (Table I). These rusts, therefore, although not identical, have many characteristics in common, which indicates that there probably is a very close relationship between the two.

A small number of experiments to test whether or not the timothy rust can be transferred by means of bridging hosts to various cereals which are not successfully infected directly from timothy were tried and it was found that by using *Avena sativa* as a bridging host the rust easily transferred to *Hordeum vulgare* (4 times in 10 trials); by using *Festuca elatior* it transferred to *Hordeum vulgare* (twice in 10 trials) and to *Triticum vulgare* (once in 10 trials); and by using *Dactylis glomerata* it transferred to *Triticum vulgare* (once in 5 trials). By the use of the bridging hosts the rust undoubtedly could be made to transfer to many grasses on which it will not grow when coming directly from timothy, but on which it might continue to grow after such a transfer. That this to some extent takes place in nature is very probable, and these trials, together with recent experiments of a similar nature on the rusts of grains,[3] throw much light on the possible origin of many of the so-called "physiological species" of rust.

ÆCIDIAL STAGE AND NOMENCLATURE OF TIMOTHY RUST.

The æcidial stage of the rust is not definitely known. Eriksson and Henning [4] noticed that the timothy in the neighborhood of barberries was not affected, while other grasses in the same locality were rusted. In two trials in 1891 they were unable to secure infection on timothy with æcidiospores from *Berberis vulgaris*. In 1892–3 æcidia on *Berberis vulgaris* were obtained by them after inoculation with teleutospores of timothy rust once in nine trials, and that in only one place of inoculation against 92 places inoculated with negative results. This one positive result may have been due to accidental infection from some other source, as two leaves on the same bush

[1] Loc. cit.

[2] Carleton, Mark Alfred. Cereal Rusts of the United States. Bulletin 16, Division of Vegetable Physiology and Pathology, U. S. Dept. of Agriculture, 1899, pp. 61–62.

[3] Freeman, E. M., and Johnson, Edward C. The Rusts of Grain in the United States. Bulletin 216, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, p. 16.

[4] Eriksson, Jakob, and Henning, Ernst. Die Haupt-Resultate einer neuen Untersuchung über die Getreideroste. Zeitschrift für Pflanzenkrankheiten, vol. 4, 1894, p. 140.

which had not been artificially inoculated also produced æcidia.[1] In 1895 Eriksson again made inoculation experiments on the barberry with the teleutospores of this rust, but in 25 inoculations none was successful.[2] In this country Kern[3] in 1908 observed eight unsuccessful inoculations on the barberry.

From their results Eriksson and Henning concluded that timothy rust does not form its æcidial stage on the barberry, while Kern[3] says that "The one positive result mentioned ought, it seems, [to] be accorded more weight than all the negative ones together, and proves that it [timothy rust] does, even if with difficulty, form its æcial stage upon the barberry." Eriksson and Henning regard the rust as a distinct species and name it *Puccinia phlei-pratensis*, while Kern considers it "a race of *Puccinia poculiformis* (*graminis*) or a so-called physiological species." Evans accepts the name *Puccinia phlei-pratensis*,[4] and in a discussion of the development of the uredo mycelia of the cereal rusts shows that there are differences in the details of infection of this rust and *Uredo graminis*, which, although slight, are well marked. In a later paper Kern[5] states that he is still of the opinion that this rust is not entitled to specific rank and would include it under "*Puccinia poculiformis* (Jacq.) Wettst.," i. e., *Puccinia graminis* Pers. He modifies his previous statement as to its being a physiological species and thinks it might better be considered a variety or subspecies, "since it does, as previously pointed out, possess some slight morphological differences from the typical form, particularly in the smaller æcial cups and the more delicate uredinial mycelium."

From the physiological specialization of this rust, as shown in experiments above reported; from its distinctive method of infection from the uredospore, as described by Evans; from the difficulty with which it produces its æcidium on barberries, as shown by Eriksson and Henning; and from the delicacy of the mycelium of the uredo stage as compared with the typical *graminis* form, as cited by Kern, it is evident that the rust of timothy has many distinctive characteristics, and, even if not well fixed, is highly specialized. Whether or not it should be regarded as a distinct species is, perhaps, debatable.

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[1] Eriksson, Jakob, and Henning, Ernst. Die Getreideroste, 1894, p. 137.

[2] Eriksson, Jakob. Ist der Timotheengrasrost eine selbständige Rostart oder nicht? Öfversigt af Kongliga Svenska Vetenskaps-Akademiens Förhandlingar, no. 5, 1902, p. 191.

[3] Kern, F. D. The Rust of Timothy. Torreya, vol. 9, January, 1909, p. 4.

[4] Evans, I. B. Pole. The Cereal Rusts. The Development of Their Uredo Mycelia. Annals of Botany, vol. 21, no. 84, 1907, pp. 446–448. "The substomatal vesicle is a very definitely shaped body closely resembling that of *Uredo graminis*, but narrower * * *. It differs from *Uredo graminis* chiefly in the fact that the end from which the hypha springs does not cling to the head of the guard cell."

[5] Kern, F. D. Further Notes on Timothy Rust. Proceedings of Indiana Academy of Science, 1909, pp. 417–418.

Some method of differentiating this rust in literature from the common *graminis* forms is necessary, however, and unless further experiments should show that it can produce its æcidium on the barberry, and until such experiments have been performed, the writer favors the use of the specific name *Puccinia phlei-pratensis* Erikss. and Henn.

WINTER SURVIVAL OF TIMOTHY RUST.

In 1908 an effort was made to determine how the rust survives the winter at the Arlington Experimental Farm. Timothy plants were removed from the field on January 19 and March 12 and were immediately potted and placed in a greenhouse at Washington, D. C., where they could be carefully watched and any further development of rust noted. Table II shows the results of these experiments.

TABLE II.—*Results of experiments on the winter survival of the rust of timothy.*

Serial No.	Placed in greenhouse.	Observations.					
		Date.	Result.	Date.	Result.	Date.	Result.
	1908.	1908.		1908.		1908.	
1	Jan. 20	Jan. 22	Four unopened pustules near tip of one leaf, several flecks in center.	Jan. 28	Pustules near tip not open, three fresh open pustules at center where flecks occurred.	Feb. 3	End of leaf dried, numerous fresh pustules over remainder of leaf.
2	...do....	...do....	No rust pustules, no flecks.	...do....	No rust.	...do....	No rust.
3	...do....	...do....	Seven unopened pustules on upper side of one leaf, several on lower.	...do....	Several fresh open pustules on both sides of leaf, several new pustules.	...do....	Leaf covered with vigorous pustules.
4	...do....	...do....	Six pustules near tip on upper side of one leaf, six on lower.	...do....	Six pustules on upper side of leaf, six on lower near tip, vigorous; three fresh pustules on upper side; three on lower near center, two of them open.	...do....	New pustules still forming, old ones vigorously producing spores.
5	...do....	...do....	One pustule on middle of upper side of one leaf, leaf partly dried.	...do....	Leaf drying.	...do....	Leaf almost dead, no new pustules.
6	Mar. 13	Mar. 13	Several pustules at base of one leaf.	Mar. 19	No further development of rust.	Mar. 25	No further development of rust.
7	...do....	...do....	Unopened pustules at base of one leaf, other leaves flecked.	...do....	Three fresh pustules on leaf; more than 2 per cent of the spores from these pustules germinated in water.	...do....	Three fresh pustules on leaf, and several fresh pustules on leaves which were flecked.
8	...do....	...do....	Unopened pustules on many leaves.	...do....	Two open pustules on one leaf.	...do....	Fresh open pustules on many leaves.
9	...do....	...do....	One pustule on each side of one leaf near tip.	...do....	No further development of rust.	...do....	No further development of rust.
10	...do....	...do....	Leaves with several unopened pustules.	...do....	.....do....	...do....	Do.

It is seen that some of the plants brought in on January 19 and March 12, notably Nos. 1, 3, 4, 7, and 8, continued to produce uredospores. At Arlington, in 1908, fresh rust pustules on new growth of timothy were common after March 15. Undoubtedly the old rust mycelium living in the plants had produced these pustules. Spores collected on January 20 and March 13, 1908, were found to be viable.

Similar conditions undoubtedly prevail in other localities of the same latitude and similar climate where this rust is found. How the rust winters farther north has not been determined, but in the light of recent investigations [1] it is very probable that it lives through the winter in the uredo stage much farther north than the latitude cited. As shown by specimens sent to the Office of Grain Investigations, it seems that teleutospores of this rust are more abundant in northern latitudes than at the Arlington Experimental Farm, where they were very scarce in 1907 and 1908. At the latter place the parasite *Darluca filum* (Biv.) Cast. largely prevents the formation of the teleuto stage, as almost every pustule ready to produce teleutospores is attacked by this fungus and further development is prevented. However, as the æcidial stage, if present, is undoubtedly rare in this country, the teleuto stage is of doubtful importance in the wintering and dissemination of the rust.

METHODS OF DISTRIBUTION OF TIMOTHY RUST.

The rapid distribution of timothy rust in recent years is doubtless due to the dissemination of the uredospore by the usual agencies. Insects have been shown to be carriers of spores,[2] birds and other animals may carry them from place to place, they may be transferred from one region to another by man through the shipment of rusted timothy hay, etc., but most important is the agency of the wind. It has been shown probable [3] that the uredospores of rusts are distributed by the wind not only from field to field, but, rising into the upper air, are carried by currents for hundreds of miles. With a quantity of uredospores on hand in various localities early in the spring, their distribution thus becomes an easy matter and the general dissemination of rust over large areas is accounted for. Undoubtedly, in the course of a few years, the distribution of this rust is to be expected over all timothy-growing sections where conditions are favorable for its development.

With the ultimate dissemination of rust over the greater part of the timothy area a practical certainty, methods of preventing any

[1] Freeman and Johnson, loc. cit.

[2] Johnson, Edward C. Floret Sterility of Wheats in the Southwest. Phytopathology, vol. 1, 1911, p. 18.

[3] Freeman and Johnson, loc. cit.; and Klebahn, H., Die wirtswechselnden Rostpilze, 1904, pp. 68–72.

considerable damage to the timothy crop from this parasite become necessary. Only one method at present known can be employed against it with any promise of success, and that is the development of varieties of timothy resistant to rust. To this end work has been commenced.

RESISTANCE OF VARIETIES OF TIMOTHY TO RUST.

A fair opportunity was offered to study the resistance of varieties of timothy to rust and to make selections for rust resistance at the Arlington Experimental Farm during 1908 and 1909, as the disease was plentiful in those years. Mr. W. J. Morse, of the Office of Forage-Crop Investigations, who had charge of timothy-breeding work at that place, says in an unpublished report:

> By July 30 (1908) no timothies were found to be entirely free from rust. * * * The rust resistance varied greatly, ranging from zero to 98 per cent. In some instances a few small rust spots appeared on the culms and no rust on the leaves. Several selections made no growth at all, the rust appearing to stunt the growth. In other instances the plants made some growth, but the production of seed was prevented. In 1909 the rust attack at the Arlington Experimental Farm was even more severe than in 1908, although the rust did not appear to any extent until the middle of May. This severe attack brought to light the fact that many of the strains marked "resistant" in 1908 appeared to be much less resistant in 1909. It was noticeable, however, that the relative resistance of the different strains was very little different in 1909 from what it was in 1908.

In 1910 the rust attack on the same farm was not nearly so severe as in the two preceding years. Under such conditions the distinction between resistant and nonresistant strains is not nearly as well marked as when rusts are abundant. As a result many strains failed to retain in their resistance percentages the same relative position which they occupied in 1908 and 1909. This corroborates the experience of the writer that the value of rust-resistance figures obtained in years when the rust is not abundant or at places where the rust attacks are not severe is questionable and shows that the notes taken at such times and places may often be misleading. Dependable data can be secured only either in "rust years" or in places where vigorous rust attacks occur or are artificially produced every year.[1]

In order to determine whether or not the figures on rust resistance obtained in the field during seasons when rust is abundant are comparable to data secured where different strains are placed under identical conditions and subjected to artificial inoculation, experiments were undertaken in 1909 in the greenhouses at Washington, D. C. Seed of various strains of timothies from the 1908 selections at the Arlington Experimental Farm was planted in 4-inch pots.

[1] Freeman and Johnson, loc. cit.

When the timothy was about 2 inches high, it was thinned to 10 plants or less in a pot and the first leaf of each plant was inoculated by placing on it, by means of a flattened inoculating needle, a small quantity of fresh uredospores. The pots were placed in a moist chamber for 48 hours, as described on page 8 of this paper, and were then removed and allowed to stand for 17 to 21 days, when final notes were taken. The percentage of noninfection from uredospore inoculations of timothy selections and the rust-resistance percentages of these selections in the field during 1908 and 1909 are shown in Table III.

TABLE III.—*The percentage of noninfection from uredospore inoculations of timothy selections and the rust-resistance percentages of these selections in the field during 1908 and 1909.*

Serial No.	Date of inoculation.	Timothy selections.	Leaves inoculated.	Leaves pustuled.	Days of incubation.	Leaves not infected.	Resistance in field. 1908	Resistance in field. 1909
	1909.		*Number.*	*Number.*	*Number.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Jan. 2	965–25	28	10	17	64	98	50
2	.....do	965–15	18	4	17	77	80	30
3	.....do	965–22	12	6	17	50	0	(1)
4	.....do	952–'04	19	12	17	37	60	....
5	.....do	952–'06	5	5	17	0	70	20
6	Jan. 9	965–18	11	6	18	46	60	....
7	.....do	29–A	14	4	18	71	98	....
8	.....do	45–B	14	9	18	36	90	30
9	.....do	967–16	11	1	18	91	0	(1)
10	Jan. 15	52–B	16	13	18	19	0	....
11	.....do	50–B	14	13	18	7	90	40
12	Jan. 20	965–'03	8	8	21	0	98	40
13	.....do	967 16	8	6	21	25	0	(1)
14	.....do	967–15	13	11	21	16	90	40
15	.....do	16	8	6	21	25	70	....
16	.....do	967–35	7	6	21	14	0	10
17	.....do	49	18	15	21	17	98	40
18	.....do	75–C	17	17	21	0	0	(1)
19	.....do	43–A	19	15	21	21	60	10
20	.....do	81	6	6	21	0	60	70
21	.....do	45–A	11	9	21	18	90	40
22	.....do	37–A	18	12	21	34	75	....
23	Jan. 23	49–A	14	7	18	50	60	20
24	.....do	952–'06	8	3	18	63	70	20

[1] Discarded.

The percentages of inoculated leaves which did not develop rust do not correspond with the rust-resistance figures obtained in the field. This is accounted for by the fact that even the most rust-resistant varieties of both grasses and cereals will develop rust to some extent when carefully inoculated in the greenhouse with the rust most common on the respective hosts. It is always noticeable, however, that although every inoculated leaf of a rust-resistant strain may be affected, the rust infection is much less severe on them than on susceptible varieties. Therefore in making observations on rust resistance not only the percentage of leaves developing rust pustules but also the severity of the infection must be considered. Although such observations are not noted in Table III it was found that, in so far as

the vigor of the infection was concerned, the relative rust resistance of strains as obtained in the field was fairly well maintained in the greenhouse experiments and that the differences in resistant and susceptible strains were marked.

Having determined, then, that there are wide differences in timothy strains with regard to resistance and susceptibility to rust, the problem in timothy-rust prevention is one of breeding. This may not be as difficult as it appears at first, since up to the present time timothies have not been highly bred and there are not only great differences between varieties but apparently unusual variations within a variety. Response to selection, therefore, may be both rapid and well marked. Such breeding, however, to be of any value must be carried on in places where the rust is abundant or where either naturally or artificially a rust attack occurs every year.

SUMMARY.

Timothy rust was reported in the United States as early as 1882. It was reported from Iowa in 1891. From 1891 to 1906 no mention of the parasite has been found. In 1906 the rust became epidemic at the Arlington Experimental Farm, near Washington, D. C., and since then has been found to be widespread, having been reported from Maine to Ontario and northern Minnesota and south to Iowa, Kentucky, and Virginia.

Timothy rust is similar in general appearance and morphological characteristics to *Puccinia graminis* Pers. on wheat.

Inoculation experiments with timothy rust at Washington, D. C., show that it can be transferred easily to various grasses. Similar results have been obtained by Eriksson in Europe. This demonstrates that the rust in the United States and the rust in Europe are identical. That it is not a well-fixed species is substantiated. By using bridging hosts timothy rust can be made to transfer to various cereals which it will not attack directly. That such transfers take place in nature to some extent is probable.

The æcidial stage of this rust is not definitely known. Eriksson and Henning in numerous inoculations with the teleutospores on barberries obtained negative results except in one instance. On this basis they consider the rust a distinct species, naming it *Puccinia phlei-pratensis*. Kern has observed several unsuccessful inoculations on the barberry in this country. From the one apparently positive result of Eriksson and Henning, however, he believes that the rust is not entitled to specific rank and should be included under *Puccinia graminis* Pers. Evans accepts the name *Puccinia phlei-pratensis* and shows that there are well-marked differences in the details of the infection from the uredospore of this rust and the *graminis* form on

cereals. From the physiological specialization of the rust, from its distinct method of uredospore infection, from the numerous negative results of inoculations with the teleutospore on barberries, and from the delicacy of the uredo mycelium, as compared with typical *graminis* forms, it is evident that this rust has many distinctive characteristics. Unless further experiments should show that the rust can produce its æcidium on the barberry and until such experiments have been performed, the writer favors the use of the specific name *Puccinia phlei-pratensis* Erikss. and Henn.

At the Arlington Experimental Farm the rust mycelium lives through the winter. It is very probable that it lives over winter in the uredo stage much farther north than the latitude cited. As the æcidial stage, if present, is undoubtedly rare in the United States the teleuto stage is of doubtful importance in the wintering and dissemination of the rust.

The rapid distribution of timothy rust in recent years is undoubtedly due to the dissemination of the uredospores by the usual agencies, namely, insects, birds, animals, man, surface winds, and upper air currents. Its ultimate distribution over all timothy-growing sections favorable to it is to be expected, and methods of preventing any considerable damage to the timothy crop become necessary.

In a study of the resistance of varieties of timothy to rust in 1908 and 1909, W. J. Morse found that the resistance "varied greatly, ranging from zero to 98 per cent." The resistance of different strains relative to each other varied little during the two years. Under a less severe rust attack in 1910 these strains in many instances failed to retain the same relative position as in previous years. This tends to show that dependable data can be obtained only when vigorous rust attacks occur.

In greenhouse experiments where strains which had been tested in the field were subjected to similar inoculation and identical conditions during the period of incubation, the percentage of inoculated leaves which did not become infected did not correspond with the figures on rust resistance obtained in the field. When the severity of infection and not the percentage of leaves developing pustules was considered, however, the relative resistance of strains as obtained in the field was fairly well maintained in the greenhouse.

As there are wide differences in timothy strains with regard to rust resistance, the problem in timothy-rust prevention becomes one of breeding. This may not be as difficult as it appears at first. Such work, however, to be of value must be carried on when the rust is abundant and where either naturally or artificially a rust attack occurs every year.

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